International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Role Of Magnetic Resonance Cholangiopancreatography (MRCP) In Determintion of Anatomical Variations of Biliary Tree and Main Pancreatic Duct

Dharmen R. Patel[1], Sunil Kast[2], Puneet Kumar Awasthi[3], Sonali Gadhavi[4], *, Ravinder Kumar Kundu[5]

[1]PG resident, Department of Radiodiagnosis Geetanjali Medical College and Hospital, Geetanjali University, Udaipur (Raj.)
[2]Associate professor, Department of Radiodiagnosis, Geetanjali medical college and hospital, Geetanjali University, Udaipur (Raj.)
[3]Associate Professor, Department of Radiodiagnosis, Geetanjali Medical college and Hospital, Geetanjali University, Udaipur (Raj.)
[4]Assistant Professor, Department of Radiodiagnosis, Geetanjali Medical college and Hospital, Geetanjali University, Udaipur (Raj.)
[5]Professor and Head, Department of Radiodiagnosis, Geetanjali Medical college and Hospital, Geetanjali University, Udaipur (Raj.)

Corresponding Author:

Dr. Sonali Gadhavi
Assistant Professor, Department of Radiodiagnosis, Geetanjali Medical college and Hospital, Geetanjali University, Udaipur (Raj.)
Email Id:
sonaligadhavi003@gmail.com

Received: 02-05-2026
Accepted: 25-05-2026
Available online: 07-06-2026

ABSTRACT

Introduction The biliary tree and pancreatic ductal system demonstrate substantial anatomical variability as a consequence of their complex embryological development. Precise knowledge of these variations is of critical importance in contemporary clinical practice, particularly in hepatobiliary surgery, liver transplantation, and interventional radiology, where unrecognized ductal anomalies are a major cause of iatrogenic bile duct injury and postoperative biliary complications.

Material and Methods This cross-sectional study was conducted in the Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Udaipur, over a period of 18 months. A total of 124 patients who underwent magnetic resonance cholangiopancreatography (MRCP) and fulfilled the inclusion criteria were enrolled using consecutive sampling. Patients with MR-incompatible devices or implants and those with inadequate visualization of the biliary or pancreatic ductal anatomy were excluded.

Results A total of 124 participants were included in the study. The study population comprised 68 males (54.8%) and 56 females (45.2%), with a predominance of rural residents (75.0%). Homemakers (35.5%) and retired individuals (25.0%) constituted the major occupational groups (Table 1). According to Huang's classification, Type A1 intrahepatic bile duct anatomy was the most common pattern, observed in 65 participants (52.4%), followed by Type A2 (21.8%) and Type A3 (16.9%.

Conclusion The present study demonstrated that anatomical variations of the biliary tree and main pancreatic duct are common findings on MRCP. Typical intrahepatic biliary anatomy was observed in only about half of the study population, while Type A2 and Type A3 were the most frequent biliary variants. Lateral mid-CBD insertion was the predominant cystic duct configuration, and pancreatic divisum was identified in 5.65% of cases.

Keywords*: Magnetic resonance cholangiopancreatography (MRCP); Biliary tree anatomy; Pancreatic duct variations; Huang classification; Pancreatic divisum.*

INTRODUCTION

The biliary tree and pancreatic ductal system demonstrate substantial anatomical variability as a consequence of their complex embryological development.[1,2] Precise knowledge of these variations is of critical importance in contemporary clinical practice, particularly in hepatobiliary surgery, liver transplantation, and interventional radiology, where unrecognized ductal anomalies are a major cause of iatrogenic bile duct injury and postoperative biliary complications.[2,3] With the widespread adoption of minimally invasive surgical techniques and image-guided procedures, accurate non-invasive pre-procedural delineation of biliary and pancreatic ductal anatomy has become an essential component of patient evaluation.[2,4]

The cystic duct most often joins the common hepatic duct from its lateral aspect in the mid-portion and usually measures 2-4 cm in length.[1,2] It follows a tortuous course and contains the spiral valves of Heister. The common bile duct descends posterior to the first part of the duodenum and the head of the pancreas before joining the main pancreatic duct at the ampulla of Vater, which opens into the second part of the duodenum through the major papilla under the control of the sphincter of Oddi. The pancreatic ductal system develops from the fusion of the ventral and dorsal pancreatic buds, with the main pancreatic duct (duct of Wirsung) draining the majority of the pancreatic parenchyma through the major papilla and the accessory duct (duct of Santorini), when present, draining through the minor papilla.[1,5]

The clinical implications of biliary and pancreatic ductal variations are substantial. In hepatobiliary surgery, unrecognized ductal anomalies increase the risk of bile duct injury, postoperative bile leaks, and biliary strictures. In laparoscopic cholecystectomy, aberrant right hepatic ducts and atypical cystic duct insertions are well-established risk factors for major bile duct injuries; preoperative delineation of ductal anatomy can help reduce such complications.[3,4] In liver transplantation, accurate preoperative assessment of donor biliary anatomy is critical, as complex ductal variants may necessitate multiple biliary anastomoses and are associated with increased postoperative morbidity.[2,6,7] Certain anatomical variants have also been linked to disease susceptibility, including an association between pancreatic divisum and pancreatitis, as well as abnormal pancreaticobiliary junctions with a long common channel and an increased risk of cholangiocarcinoma and gallbladder carcinoma.[3,5,8]

Magnetic resonance cholangiopancreatography has emerged as a key non-invasive modality for evaluating the biliary tree and pancreatic ductal system. Compared with invasive techniques such as endoscopic retrograde cholangiopancreatography and intraoperative cholangiography, MRCP offers a safer alternative with high diagnostic accuracy for anatomical delineation and is particularly suitable for preoperative evaluation.[2,4] Furthermore, MRCP allows comprehensive assessment of both the biliary and pancreatic ductal systems in a single examination, making it well suited for population-based studies estimating the prevalence of anatomical variations.[2,8]

The present study aims to evaluate the prevalence of anatomical variations of the intrahepatic bile ducts, cystic duct, and main pancreatic duct using 3-Tesla magnetic resonance cholangiopancreatography, thereby providing clinically relevant data to assist radiologists and surgeons in improving preoperative planning and minimizing procedure-related complications.

MATERIAL AND METHODS

This cross-sectional study was conducted in the Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Udaipur, over a period of 18 months. A total of 124 patients who underwent magnetic resonance cholangiopancreatography (MRCP) and fulfilled the inclusion criteria were enrolled using consecutive sampling. Patients with MR-incompatible devices or implants and those with inadequate visualization of the biliary or pancreatic ductal anatomy were excluded. All participants underwent MRCP using a 3-Tesla SIGNA ARCHITECT MRI scanner after a fasting period of 4–6 hours. The obtained MRCP images were analyzed for anatomical variations of the intrahepatic bile ducts, cystic duct and its insertion, and the main pancreatic duct. Data were recorded in a structured proforma and analyzed using appropriate statistical methods. Descriptive statistics were expressed as frequencies and percentages, and associations between variables were assessed using relevant statistical tests. A p-value of <0.05 was considered statistically significant

RESULTS

A total of 124 participants were included in the study. The study population comprised 68 males (54.8%) and 56 females (45.2%), with a predominance of rural residents (75.0%). Homemakers (35.5%) and retired individuals (25.0%) constituted the major occupational groups (Table 1). According to Huang's classification, Type A1 intrahepatic bile duct anatomy was the most common pattern, observed in 65 participants (52.4%), followed by Type A2 (21.8%) and Type A3 (16.9%). Type A5 was the least common variant (1.6%) (Table 2). No significant association was observed between gender and intrahepatic bile duct anatomy ($\chi^2 = 3.96$, $p = 0.41$), indicating a comparable distribution of anatomical variants among males and females (Table 3). Normal main pancreatic duct anatomy was identified in the majority of participants (91.1%). Pancreatic divisum was present in 5.6%, whereas meandering main pancreatic duct and anomalous pancreaticobiliary duct junction were observed in 2.4% and 0.8% of cases, respectively (Table 4). The distribution of main pancreatic duct anatomy did not differ significantly between males and females ($\chi^2 = 0.19$, $p = 0.90$), suggesting no gender-related variation in pancreatic ductal anatomy (Table 5). Regarding cystic duct anatomy, lateral insertion of the cystic duct into the mid common bile duct was the predominant pattern, occurring in 67.7% of participants. Other variations included low posterior insertion (9.7%), high insertion (8.9%), low medial insertion (5.6%), posterior insertion in the mid CBD (4.8%), and medial insertion in the mid CBD (2.4%) (Table 6).

Table 1. Baseline Characteristics of Study Participants (n = 124)

Variable	Category	n (%)
Gender	Male	68 (54.8)
	Female	56 (45.2)
Residence	Rural	93 (75.0)

	Urban	31 (25.0)
Occupation	Homemaker	44 (35.5)
	Retired	31 (25.0)
	Farmer	16 (12.9)
	Shopkeeper	8 (6.5)
	Private Job	7 (5.6)
	Daily Wage Worker	5 (4.0)
	Government Employee	4 (3.2)
	Student	4 (3.2)
	Businessman	3 (2.4)
	Others	2 (1.6)

Table 2. Distribution of Intrahepatic Bile Duct Anatomy According to Huang Classification

Huang Classification	**n (%)**
Type A1	65 (52.4)
Type A2	27 (21.8)
Type A3	21 (16.9)
Type A4	9 (7.3)
Type A5	2 (1.6)
Total	**124 00)**

Table 3: Association Between Gender and Intrahepatic Bile Duct Anatomy

Huang Classification	**Male n**	**Female n**	**Total**
Type A1	12	15	27
Type A2	11	10	21
Type A3	4	5	9
Type A4	39	26	65
Type A5	2	0	2
P value	0.41		

Table 4. Main Pancreatic Duct Anatomy

Type of Main Pancreatic Duct Anatomy	**n (%)**
Normal	113 (91.1)
Pancreatic Divisum	7 (5.6)
Meandering Main Pancreatic Duct	3 (2.4)
Anomalous Pancreaticobiliary Duct Junction	1 (0.8)
Total	**124 00)**

Table 5. Association Between Gender and Main Pancreatic Duct Anatomy

Pancreatic Duct Anatomy	**Male**	**Female**	**Total**
Normal	62	52	114
Pancreatic Divisum	4	3	7
Meandering MPD	2	1	3
P value	0.9		

Table 6. Cystic Duct Anatomy and Insertion Pattern

Cystic Duct Anatomy	**n (%)**
Lateral insertion into mid CBD	84 (67.7)
Posterior insertion into mid CBD	6 (4.8)
Medial insertion into mid CBD	3 (2.4)
High insertion	11 (8.9)
Low insertion along medial CBD	7 (5.6)
Low insertion along posterior CBD	13 (9.7)
Total	**13 00)**

DISCUSSION

The present study was conducted to evaluate anatomical variations of the biliary tree and main pancreatic duct using Magnetic Resonance Cholangiopancreatography (MRCP) in a tertiary care setting. MRCP is a reliable, non-invasive

imaging modality that provides excellent delineation of the biliary and pancreatic ductal systems and plays an important role in preoperative planning and the prevention of surgical complications.

The study population predominantly comprised middle-aged and elderly individuals, with the highest proportion belonging to the 51–60-year age group. No significant association was observed between age and biliary or pancreatic ductal variations, indicating that these anatomical configurations are congenital in origin and remain stable throughout life. Similar observations have been reported in previous MRCP-based studies.[9] Likewise, gender did not demonstrate a significant association with ductal variants, which is consistent with the findings of Aljiffry et al. [10] and the large meta-analysis by Janssen et al. [11] These findings reinforce the concept that anatomical variations are developmental rather than demographic phenomena.

The most important finding of the present study was the high prevalence of intrahepatic biliary variations. Using the Huang classification system, Type A1 (normal anatomy) was identified in 52.42% of participants, whereas nearly half exhibited variant anatomy. This prevalence of normal anatomy was slightly lower than that reported by Gupta et al.[5] and Janssen et al. [11] The use of high-resolution 3-Tesla MRCP in the present study may have contributed to better detection of subtle variants, as previously suggested by Mazroua et al. [12]

Among the variants, Type A2 (triple confluence) and Type A3 (right posterior sectoral duct draining into the left hepatic duct) were the most frequent. Type A2 anatomy is of particular surgical significance because trifurcation patterns increase the risk of inadvertent biliary injury during hepatobiliary procedures. Similarly, Type A3 anatomy has important implications in liver transplantation and laparoscopic cholecystectomy because the aberrant duct crossing the hilar plate is highly susceptible to injury. Comparable frequencies have been reported by Gupta et al., Janssen et al., and El Hariri and Riad [11,13] Sureka et al. [14] and Sarawagi et al. [15] further emphasized the clinical importance of recognizing these variants before surgery.

Type A4 and Type A5 variants were less common but clinically significant. Type A4 anatomy, characterized by direct drainage of the right posterior sectoral duct into the common hepatic duct, poses a substantial risk during dissection within Calot's triangle. Type A5, although rare, represents one of the most hazardous configurations because transection of the cystic duct during cholecystectomy may inadvertently divide the aberrant duct, resulting in serious postoperative complications.

Evaluation of cystic duct anatomy revealed considerable heterogeneity. Lateral insertion into the mid common bile duct was the most common configuration, observed in 67.74% of cases, consistent with previous studies. Variants such as low insertion, high insertion, and medial insertion are of particular surgical importance because they increase the likelihood of bile duct injury and technical difficulties during laparoscopic cholecystectomy. Taghavi et al. [16] and Rhaiem et al. [17] highlighted the value of preoperative MRCP in identifying these potentially dangerous anatomical patterns.

Assessment of the pancreatic duct demonstrated normal anatomy in 91.13% of participants. Pancreatic divisum was the most common pancreatic duct variant, identified in 5.65% of cases, which corresponds closely with the prevalence reported in MRCP literature. Although pancreatic divisum is frequently asymptomatic, it has been implicated in recurrent pancreatitis in susceptible individuals. Bertin et al. [18] suggested that pancreatic divisum acts as a cofactor rather than an independent cause of pancreatitis, while Sandrasegaran et al. [19] emphasized the utility of secretin-enhanced MRCP in evaluating functional obstruction associated with this anomaly.

Less common pancreatic variants included meandering main pancreatic duct and anomalous pancreaticobiliary duct junction (APBDJ). The latter, although identified in only one patient, is clinically significant because of its established association with biliary malignancy and chronic biliary inflammation.[23] Early identification through MRCP facilitates timely intervention and long-term surveillance.

Overall, the present study demonstrates that biliary and pancreatic ductal variations are common findings on MRCP and possess considerable clinical relevance. Accurate preoperative identification of these variations is essential for hepatobiliary surgery, liver transplantation, and endoscopic interventions. The findings support the routine use of MRCP in selected patients with suspected complex biliary anatomy, as it provides a detailed anatomical roadmap that can reduce operative complications and improve patient outcomes.

CONCLUSION

The present study demonstrated that anatomical variations of the biliary tree and main pancreatic duct are common findings on MRCP. Typical intrahepatic biliary anatomy was observed in only about half of the study population, while Type A2 and Type A3 were the most frequent biliary variants. Lateral mid-CBD insertion was the predominant cystic duct configuration, and pancreatic divisum was identified in 5.65% of cases. These variations have important implications for hepatobiliary surgery, liver transplantation, and endoscopic procedures. MRCP proved to be a valuable, non-invasive modality for accurate preoperative mapping of ductal anatomy, helping reduce the risk of iatrogenic biliary injury. The

absence of significant associations with sociodemographic factors further supports the congenital nature of these anatomical variations.

REFERENCES:

1. Sutton D. Textbook of radiology and imaging 7th Ed. 7th ed. Churchill Livingstone; 2003.
2. Sureka B, Bansal K, Patidar Y, Arora A. Magnetic resonance cholangiographic evaluation of intrahepatic and extrahepatic bile duct variations. Indian J Radiol Imaging. 2016 Feb 1;26(1):22–32. doi:10.4103/0971-3026.178283 PubMed PMID: 27081220.
3. Aljiffry M, Abbas M, Wazzan M, Abduljabbar A, Aloufi S, Aljahdli E. Biliary anatomy and pancreatic duct variations: A cross-sectional study. Saudi J Gastroenterol. 2020 Jul 1;26(4):188–93. doi:10.4103/SJG.SJG_573_19 PubMed PMID: 32461381.
4. Rhaiem R, Piardi T, Renard Y, Chetboun M, Aghaei A, Hoeffel C, et al. Preoperative magnetic resonance cholangiopancreatography before planned laparoscopic cholecystectomy: is it necessary? J Res Med Sci. 2019 Jan 1;24(1):107. doi:10.4103/JRMS.JRMS_281_19 PubMed PMID: 31949458.
5. Kuzel AR, Lodhi MU, Rahim M. Pancreatic Divisum: An Unusual Cause of Chronic Pancreatitis in a Young Patient. Cureus. 2017 Nov 17;9(11):e1856. doi:10.7759/CUREUS.1856 PubMed PMID: 29375942.
6. Sarawagi R, Sundar S, Raghuvanshi S, Gupta SK, Jayaraman G. Common and Uncommon Anatomical Variants of Intrahepatic Bile Ducts in Magnetic Resonance Cholangiopancreatography and its Clinical Implication. Pol J Radiol. 2016 May 26;81:250–5. doi:10.12659/PJR.895827 PubMed PMID: 27298653.
7. El Hariri M, Riad MM. Intrahepatic bile duct variation: MR cholangiography and implication in hepatobiliary surgery. Egyptian Journal of Radiology and Nuclear Medicine 2019 50:1. 2019 Dec 12;50(1):78. doi:10.1186/S43055-019-0092-X
8. Gupta A, Rai P, Singh V, Gupta RK, Saraswat VA. Intrahepatic biliary duct branching patterns, cystic duct anomalies, and pancreas divisum in a tertiary referral center: A magnetic resonance cholangiopancreaticographic study. Indian J Gastroenterol. 2016 Sep 1;35(5):379–84. doi:10.1007/S12664-016-0693-5 PubMed PMID: 27660206.
9. Sutton D. Textbook of Radiology and Imaging. 7th ed. Churchill Livingstone; 1075-7; 2003.
10. Aljiffry M, Abbas M, Wazzan MA, Abduljabbar AH, Aloufi S, Aljahdli E. Biliary anatomy and pancreatic duct variations: a cross-sectional study. Saudi Journal of Gastroenterology. 2020 Jul;26(4):188–93.
11. Janssen B V, van Laarhoven S, Elshaer M, Cai H, Praseedom R, Wang T, et al. Comprehensive classification of anatomical variants of the main biliary ducts. British Journal of Surgery. 2021 May;108(5):458–62.
12. Mazroua JA, others. Precision Mapping of Intrahepatic Biliary Anatomy and Its Anatomical Variants Having a Normal Liver Using 2D and 3D MRCP. Diagnostics. 2023;13(5):1–15.
13. Gupta A, Rai P, Singh V, Gupta RK, Saraswat VA. Intrahepatic biliary duct branching patterns, cystic duct anomalies, and pancreas divisum in a tertiary referral center: A magnetic resonance cholangiopancreaticography study. Indian Journal of Gastroenterology. 2016 Sep;35:379–84.
14. Sureka B, Bansal K, Patidar Y, Arora A. Magnetic resonance cholangiographic evaluation of intrahepatic and extrahepatic bile duct variations. Indian Journal of Radiology and Imaging. 2016 Jan;26(01):22–32.
15. Sarawagi R, Sundar S, Raghuvanshi S, Gupta SK, Jayaraman G. Common and Uncommon Anatomical Variants of Intrahepatic Bile Ducts in Magnetic Resonance Cholangiopancreatography and its Clinical Implication. Pol J Radiol. 2016;81:250–5.
16. Taghavi A, Azizi M, Rasekhi A, Gholami Z. Anatomic Variations of the Cystic Duct in Magnetic Resonance Cholangiopancreatography in Shiraz: A Cross-Sectional Study. Iran J Med Sci. 2022;47(1):48.
17. Rhaiem R, Piardi T, Renard Y, Chetbour M, Aghaei A, Hoeffel C, et al. Preoperative magnetic resonance cholangiopancreatography before planned laparoscopic cholecystectomy: is it necessary? Journal of Research in Medical Sciences. 2019 Jan;24(1):107.
18. Bertin C, others. Pancreas divisum is not a cause of pancreatitis by itself but acts as a partner of genetic mutations. American Journal of Gastroenterology. 2012;107(2):311–7.
19. Sandrasegaran K, others. The Value of Secretin-Enhanced MRCP in Patients With Recurrent Acute Pancreatitis. AJR Am J Roentgenol. 2017;208(2):315–21.